Passivhaus Institut
Rheinstr. 44/46, 64283 Darmstadt
Tel +49 (0)6151/826 99 0
Fax +49 (0)6151/826 99-11
mail@passiv.de / www.passiv.de

# Requirements and testing procedures for energetic and acoustical assessment of Passive House ventilation systems < 600 m³/h for Certification as "Passive House suitable component"

For the certification of a ventilation unit as a "Passive House suitable component" by the Passive House Institute, at least the following measurements should be commissioned to a PHI-approved independent inspecting authority. All measured data and documentation of that authority must be made available to the PHI.
The manufacturer must provide the independent authority with a serial unit for testing. Specially prepared appliances will not be accepted for testing and must be taken back at the cost of the manufacturer. The inspecting authority must guarantee a testing procedure in accordance with these testing regulations.

### 1. Experiment set-up

The siphon of the condensate drain is to be filled with water and the ventilation unit is to be installed and started according to the manufacturer's instructions.

### The fine filter

Before the start of the testing the type and model of the built-in filters should be checked. On the outdoor air side a filter of efficiency ISO ePM1 50%, on the extract air side of efficiency ISO Coarse 60% is to be inserted. If it is not possible to insert an ISO ePM1 50% filter, an external filter box with an ISO ePM1 50% filter is to be specified and delivered by the manufacturer and integrated into the experiment. Any integrated outdoor air filter of lesser quality can then be removed.
An external filter unit is attached to the nozzles of the unit and treated as part of the apparatus for all tests. The decrease in pressure of the external filter unit, its leakages and heat flow through the filter housing all contribute to the experimental data for the unit: air conditions and flow rate are thus measured before entering the external additional attachment.

## Anti-freeze protection of the heat exchanger

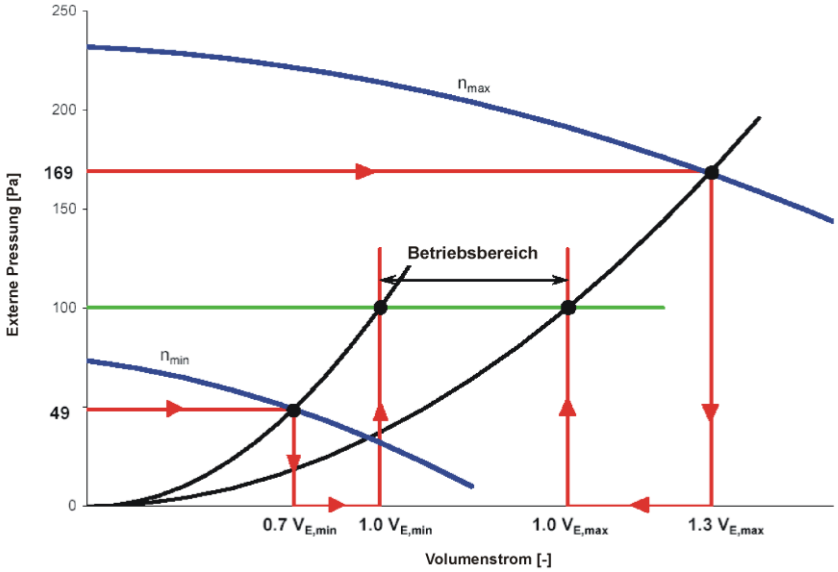
It should be checked that a frost protection device for the heat exchanger (i.e. heater coils) is installed. If this is not the case, an external frost protection with all relevant controls is to be specified and delivered by the manufacturer and integrated into the experiment set-up. An external unit is attached to the nozzles of the unit and treated as part of the apparatus for all tests. The decrease in pressure of the external frost protection unit, as well as its air leakage and heat flow through the housing all contribute to the performance of the apparatus: air conditions and flow rate are thus measured before entering the external additional attachment.

## Emergency shutdown for frost protection

Likewise it should be checked that the ventilation unit has an integrated emergency shutdown for critically low supply air temperatures (to protect the heater coils from freezing up). If not, then an external appliance with its factory setting is to be delivered by the manufacturer, and this will be a part of the experimental set-up. If the emergency shutdown is only possible through an external device, it should be clearly and visibly set out in the assembly instructions that its use is compulsory for Passive Houses with hydraulic supply air heater coils.

## 2. Operational range and flow rates for the test

The limits of the operational range are defined with the experimental set-up according to 1 as follows:




a) The unit is operated at full speed with an external pressure of 100 Pa x $1,3^2$ = 169 Pa. The flow rate measured divided by 1.3 gives the upper limit of the operational range.
b) The unit is operated with an external pressure of 100 Pa x $0,7^2$ = 49 Pa at the lowest fan speed. The measured flow rate divided by 0.7 gives the lower limit of the operational range.
c) The flow rate for the test is computed from the average value of the upper and lower limits of the operational area.
d) If the proportion of the upper and lower limits is greater than 1.6:1, several test series are to be taken. The total operational range is divided up into equal parts which must be proportionally less than 1.6:1. Within these partial areas measurements should be made using mid flow rate values.

The rated flow rate in all cases is the supply air flow rate. The external pressure to be applied for the measurements is to be distributed evenly (i.e. 50% at a time) across the suction side and pressure side.

## 3. Testing of airtightness

The experiment set-up follows the Nordtest method [NT VVS 022 HEATRECOVERY Units, internal Leakage; NT VVS 023 HEATRECOVERY Units, external Leakage]. The internal and external airtightness of the test object is to be investigated. The airtightness test for negative pressure as well as for over-pressure is to be carried out before starting the thermo-dynamical testing. The measurements should be made for at least four testing pressures at a time in the range between 50 Pa and 300 Pa.

a) External leakage: the air flow rate which is necessary to maintain the static pressure difference between the apparatus interior and the surroundings is determined.
b) Internal leakage: The air flow rate between the extract air/exhaust air side and outdoor air/supply air side is ascertained by sealing the extract air/exhaust air side and putting it under negative/over-pressure. Between the surrounding air and the outdoor air/supply air side a pressure difference of 0 Pa is adjusted using an auxiliary fan. The internal leakage flow rate is represented by the input and discharge flow rates which are necessary for adjustment of the pressure difference of 0 Pa.

The leakage for both the over-pressure and negative pressure is given as standardised for 100 Pa by using the regression line computed from the measurement readings. As a result of the airtightness test the respective average value is calculated from the over-pressure and negative pressure tests. All readings are to be documented in the test report.
The leakages determined should not be greater than 3 % of the mid flow rate of the operational range of the ventilation equipment as defined in paragraph 2. The rated flow rate is the supply air flow rate.

## 4. Thermo-dynamical testing

The external pressure for the measurements is generally 100 Pa. The applied external pressure decrease should be evenly distributed (i.e. 50 % at a time) across the suction side and pressure side.

a) The mass flows of the outdoor air and exhaust air are to be balanced within the precision of the measurements by adjustment of the fans (except for automatically balanced fans).
b) All flow rates (outdoor air /exhaust air and supply air/extract air) are measured and logged.
c) The air temperature and humidity is measured and logged for all flows (outdoor air /exhaust air and supply air/extract air).
d) The outdoor air temperature is to be set as low as possible, but sufficiently high enough to ensure that no condensation can occur in the heat exchanger due to the humidity present in the outdoor air and extract air.
e) During the measurements the total electrical power consumption of the apparatus (including the controls and also of any necessary external systems etc) should be ascertained and logged.

The air flow rate/rates for the measurement(s) should be assessed according to the instructions in paragraph 2. The rated flow rate is the supply air flow rate. It should be ensured and substantiated through the recorded measurement data for all series of measurements that the whole experimental set-up has achieved a steady state.

## Apparatus with manual mass flow balance

The effective dry heat recovery rate must be higher than 75 % with balanced mass flows of the outdoor air and exhaust air, at outdoor air temperatures between – 15 and + 10 °C and dry extract air (ca. 20 °C).

$$\eta_{WRG,t,eff} = \frac{(\vartheta_{AB} - \vartheta_{FO}) + \frac{P_{el}}{\dot{m} \cdot c_p}}{(\vartheta_{AB} - \vartheta_{AU})} \qquad [1]$$

From the documentation of the apparatus it should be clearly identifiable how the adjustment of fans for establishing the outdoor air/exhaust air side mass flow balance and the adjustment to the loss of pressure of a given duct system can take place.

## Apparatus with constant flow rate fans

The mass flow balance for ventilation units with constant flow rate fans is automatically achieved on the outdoor air/exhaust air side, but there is a deviation of some per cent. An imbalance of less than 10% is acceptable. If the possibility of manual readjustment of the balance is available, this should be done before the start of the measurements.

The remaining imbalance should be dealt with in the following manner: In the case of an excess of outdoor air the exhaust air temperature is to be mathematically corrected by admixture at extract air temperature as follows:

$$\vartheta_{FO,korr} = \frac{(\dot{m}_{Dis} \cdot \vartheta_{AB} + \dot{m}_{FO} \cdot \vartheta_{FO})}{\dot{m}_{AU}} \qquad [2] \qquad \text{with} \qquad \dot{m}_{Dis} = \dot{m}_{AU} - \dot{m}_{FO} \qquad [3]$$

It applies that:

$$\eta_{WRG,t,eff} = \frac{(\vartheta_{AB} - \vartheta_{FO,korr}) + \frac{P_{el}}{\dot{m} \cdot c_p}}{(\vartheta_{AB} - \vartheta_{AU})} \qquad [4]$$

From the documentation of the unit it must be clearly identifiable, if necessary, how the readjustment of the fans to optimise the outdoor air/ exhaust air side mass flow balance and the adjustment to the loss of pressure of a given duct system can take place.

## 5. Electrical efficiency

The total electrical power consumption of the ventilation apparatus (all fans, controls, and any essential external systems) should at the upper limit of the operational range not exceed 0.45 W/(m³/h) for transported supply air flow. The freeze protection for the heat exchanger remains disabled. The test is carried out at external pressure of 100 Pa (see paragraph 2).

## 6. Acoustical testing

### Emission spectrum

The measurement of the acoustic power emitted by the ventilation unit takes place according to DIN EN ISO 3743-1 (positioning of the unit in the testing room according to manufacturer's instructions). Additionally the acoustic power in the outdoor/exhaust/supply and extract air ducts is measured according to DIN EN ISO 5136 (Oct. 2003). The measurement readings are given in third octave bands (31.5 Hz – 8000 Hz). All tests are carried out at an external pressure of 100 Pa and using the upper limit of the operational range as the flow rate (see paragraph 2).

### Sound emission of the apparatus

Entirely Passive House-suitable units have a noise level of ≤ 35 dB(A) in a room with an equivalent absorption area of 4 m². They can thus be operated without further measures in any functional room (e.g. kitchen, bathroom). If this value is exceeded, a certificate can only be issued with the restriction that the device should be installed in a separate utility room or the like.

#### Recommendation for silencers

Suggestions for appropriate silencers for the supply air and extract air ducts are to be made by the manufacturer on the basis of the measured emissions. Because the duct systems in Passive Houses are optimised and may be very short, silencers are to be dimensioned without accounting for a damping action by the duct system. The adoption of the damping action of a standard supply air or extract air outlet is tolerable.

In living areas (supply air) a noise level of ≤ 25 dB(A), while in functional rooms (extract air) a noise level of ≤ 30 dB(A) is stipulated.
If there is no recommendation by the manufacturer, exemplary guidelines on the basis of standard values of typical silencers are provided by the PHI.

## 7. Frost protection shutdown for hydraulic heater coils in the supply air

In order to avoid frost damage to any downstream hydraulic heater coils (Passive House supply air heating) the apparatus must have an emergency shutdown if the supply air temperature falls below +5°C (e.g. malfunction of exhaust air fan). For the user a clearly perceptible corresponding error message should be issued at the control unit.

The testing involves the closing of the extract air duct and parallel decrease in the outdoor air temperature. The temperature profile of the air flows, the development of the flow rates and the electrical power consumption of the apparatus are to be described in the test report.

### 8. Checking of the frost protection for the heat exchanger

## Switching threshold of the factory setting

The frost protection of the apparatus must guarantee regular operation, that is, with mass flow balance on the outdoor air/ exhaust air side and undiminished mass flow, at all times. For this a suitable preheater is necessary (cf. 1).
This should be operated in the factory setting as delivered by the manufacturer. The outdoor air temperature at which the pre-heating is activated should be ascertained by measurement, with a standardised extract air condition of 21°C /50 % rH. The switching threshold for the frost protection must be –3°C or less. The temperature profile of the air flows, air humidity and the development of the flow rates as well as the electrical power consumption of the apparatus are to be described in the test report.

## The effectiveness of the freeze-protection

The effectiveness of the freeze-protection is to be proved in a twelve-hour long-term test with an external air temperature of –15°C and standardised extract air condition of 21°C /50% rH. A visual inspection of the heat exchanger for ice deposits ends this part of the examination. The test is to be carried out using the flow rate of the upper limit of the operational range. The temperature profile of the air flows, air humidity and the development of the flow rates as well as the electrical power consumption of the apparatus are to be described in the test report.

## Measurement of the critical temperature

The temperature at which the exhaust air temperature reaches the frost limit should be determined with deactivated pre-heating. This critical temperature for the inside positioning of the apparatus should be documented. The test is carried out using the mid flow rate of the operational range. The temperature profiles of the air flows, air humidity and the development of the flow rates as well as the electrical power consumption of the apparatus are to be described in the test report.
For a minimised frost protection energy demand it should be possible to set the limit temperature so that no frost can occur in the heat exchanger.

The approach for the manual readjustment of the frost protection limit temperature must be clearly described in the assembly instructions supplied with the apparatus. The factory setting must, however, guarantee the maximum temperature of –3°C.

### 9. Comfort criterion

The observation of a minimal supply air temperature of 16.5 °C at –10 °C outdoor air temperature is to be proved by measurement. A frost protection unit for the heat exchanger is active with its factory setting in this test. The temperature profile of the air flows, air humidity and the development of the flow rates as well as the electrical power consumption of the apparatus are to be described in the test report.

## 10. Ascertainment of the standby loss

The electrical power consumption of the ventilation unit (including controls, also any essential external systems) is to be ascertained for the purely stand-by operation of the apparatus. In the stand-by mode a consumption of 1 W should not be exceeded, otherwise the manufacturer should provide the possibility of a complete disconnection from the electrical supply as a standard.

## 11. Restart after a power failure

It must be ensured that the apparatus automatically starts regular operation after a power failure without any user intervention. The operation must be continued at the same setting as before the power failure. The test is to be carried out by pulling out the mains plug and waiting for ten minutes.

## 12. Hygiene

Inspection and cleaning of the central apparatus including the heat exchanger should be easy. It must be possible for the user to change the filters himself (no expert should be required for this), a description for this procedure and suppliers for the spare filters should be documented in the handbook.
The service life of the outdoor air filter should be limited to one year (to avoid endotoxins). The manufacturer must ensure that the proliferation of microorganisms and the entry of endotoxins is prevented permanently by providing either components or obligatory attachments for the apparatus.

## 13. Miscellaneous

All specified test procedures apply for typical cases. For unusual construction types alternative or additional testing may be necessary. It is recommended that this is agreed at an early stage with the Passive House Institute.
If, due to the available facilities in a certain laboratory, individual air conditions cannot be achieved, after early agreement with the PHI an arrangement should be made which approximates the intentions of the requirements as much as possible.

## 14. Symbols and abbreviations

| | | |
|---|---|---|
| AU | Outdoor air | [-] |
| FO | Exhaust air | [-] |
| ZU | Supply air | [-] |
| AB | Extract air | [-] |
| $\vartheta_{AU}$ | Outdoor air temperature | [°C] |
| $\vartheta_{FO}$ | Exhaust air temperature | [°C] |
| $\vartheta_{FO,korr}$ | Corrected exhaust air temperature | [°C] |
| $\vartheta_{ZU}$ | Supply air temperature | [°C] |
| $\vartheta_{AB}$ | Extract air temperature | [°C] |
| $\dot{m}$ | Mass flow | [kg/h] |
| $\dot{m}_{Dis}$ | Mass flow difference/imbalance | [kg/h] |
| $\dot{m}_{AU}$ | Mass flow outdoor air | [kg/h] |
| $\dot{m}_{FO}$ | Mass flow exhaust air | [kg/h] |
| $c_p$ | Specific thermal capacity of air | [Wh/(kg K)] |
| $P_{el}$ | Real electrical power | [W] |
| $\eta_{WRG,t,eff}$ | Effective heat recovery | [%] |

**Passive Houses have high requirements for the quality of the applied components because they can dispense with a separate heating system. A highly efficient heat recovery apparatus is an essential component of the comfort ventilation in a Passive House.**
**The following requirements have been stipulated by the PHI for the certification as "Passive House suitable component – heat recovery device" (details and explanations can be found in the appendix of the certificate):**

| | |
|---|---|
| **Passive House - comfort criterion** | Minimum supply air temperature of 16.5°C |
| **Efficiency criterion** (Heat) | The effective dry heat recovery efficiency must be higher than 75 % with balanced mass flows at external temperatures of between – 15 and + 10 °C and dry extract air (ca. 20 °C). $\eta_{WRG,t,eff} = \frac{(\vartheta_{Ab} - \vartheta_{Fo}) + \frac{P_{el}}{\dot{m} \cdot c_p}}{(\vartheta_{Ab} - \vartheta_{Au})}$ |
| **Electrical efficiency criterion** | At the designed mass flow rate the total electrical power consumption of the ventilation device may not exceed 0.45 W per (m³/h) of transported supply air flow. |
| **Balancing and controllability** | Outdoor air and exhaust air mass flows must be balanceable for the rated air flow rate, with controllability of at least 3 levels (basic ventilation (70-80%), standard ventilation (100%), increased ventilation (130%)). |
| **Sound absorption** | Noise level in installation room < 35 dB(A),<br>in living areas < 25 dB(A),<br>in functional areas < 30 dB(A). |
| **Room air hygiene** | Outdoor air filter at least ISO ePM1 50%, extract air filter at least ISO Coarse 60% |
| **Frost protection** | Frost protection for heat exchanger without supply air interruption, frost protection for an air heater in case of failure of the extract air fan or frost protection heater coil |

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Fax +49 (0)6151/826 99-11
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# Requirements and testing procedures for energetic and acoustical assessment of Passive House ventilation systems < 600 m³/h for Certification as "Passive House suitable component"

## Supplementary test of frost protection - Preliminary

### Preface

The existent document complements the requirements and testing procedures for passive house ventilation systems < 600 m³/h [1]. This document replaces the testing of the frost protection according to [1] point 8 as well as the testing of the comfort criterion according to [1] point 9.
Within the next revision of the requirements and testing procedure [1], the existent document will be considered, and supplementary sheet and testing procedure will be combined to one document.

### Requirements concerning the frost protection strategy for the heat exchanger

In order to utilize heat recovery ventilation units in passive houses with optional supply air heating, an operation of the heat recovery unit without interruption of the supply air flow rate is mandatory. The mass flows must remain in balance even at low outdoor air temperatures. The maximum imbalance allowed is 10%.

The automatic threshold for activating the frost protection strategy can vary depending on the heat recovery rate and the frost protection strategy. In order to achieve an efficient operation of the device during low outdoor air temperatures, the automatic threshold should be ≤ -3°C. The efficiency of the frost protection strategy mainly depends on the control strategy. Controlling the frost protection energy only based on the outdoor air temperature (before the heater coil) without controlling the power output can't be an acceptable frost protection strategy.
Furthermore the average exhaust air temperature mustn't exceed 5°C.

### Requirements concerning a comfortable supply air temperature at low outdoor air temperatures

A minimum supply air temperature of 16,5°C should be maintained at outdoor air temperatures of -10°C and extract air temperatures of 21°C [1)] (under standard frost protection settings).

1) The requirement doesn't comply with the measurement. Proving the requirements is generated with calculations based on the measurement.

With some frost protection strategies the comfort criterion might not be full filled (e.g. outdoor – supply air bypass, rotor heat exchanger). In this case the manufacturer should provide measures for compensation (e.g. supply air heater).

**Required data/ documentation to be provided by the manufacturer**

In order to evaluate the frost protection strategy as well as to check possible deviation from the testing requirements, a detailed description of the frost protection strategy with recommendations respecting the nominal values of the control variable as well as the capacity of pre heater or supply air heater (if installed in the device) is mandatory.

In case that the frost protection strategy is based on an external heat exchanger, a data sheet of the pre heater is required with technical data and installation instruction.

In order to check possible deviation from the testing requirements, the manufacturer documentation of the frost protection strategy should be handed in preferentially before the measurement starts.

**Description of the measurements**

a) Settings of ventilation device

The settings of the ventilation device especially the settings respecting the frost protection strategy should remain as default/ should be set according to manufacturer information. If changes of the default settings should be required in order to fulfill the requirements, the documentation of the changes in the measurement report is mandatory.

If the frost protection strategy is based on an external heating device, it must be installed according to manufacturer recommendations. The documentation of the installation situation as well as optional minimum distance between heater and ventilation device (if required) in the measurement report is required.

b) Measurement condition

The measurement of the frost protection strategy should be conducted under following conditions, in accordance with DIN EN 13141-7:

- Air flow rate at the upper limit of the certified air flow range (in accordance to [1]) or, alternatively, at a higher air flow rate
- Outdoor air temperature: -15°C
- Extract air temperature: 20°C/ relative humidity: 25% – 40%
- Duration of measurement from steady state of the air flow rates at -15°C outdoor air temperature on: minimum 6 h

The air flow rates must be adjusted to a balanced operation mode before the measurement or in the beginning of the measurement.

From 0°C on the outdoor air temperature should decrease gradually until reaching the test temperature of -15°C. The activation of the frost protection strategy should be documented with time, outdoor air temperature and exhaust air temperature.

The air condition should remain constant temporary at an outdoor air temperature of -10°C. When reaching a steady state (e.g. after 30 minutes), the supply air temperature is to be documented in the measurement report.

Afterwards the outdoor air temperature decreases until the testing temperature of -15°C.

Alternatively to the before described procedure the test for determining the supply air temperature at an outdoor air temperature of -10°C could also be conducted separately (lowering the outdoor air temperature during the test of the frost protection strategy should occur without interruption, then).

During the whole measurement the following parameter must be logged:

- Air flow rates (SUP, ODA, ETA, EHA)
- Temperatures (ODA, SUP, ETA, EHA)
- Electric power input of frost protection strategy or optional of the whole ventilation device (including frost protection)

In order to evaluate the frost protection efficiency in future, recording the power consumption of the frost protection strategy (alternatively of the whole device) in a defined time frame (recommendation: 6h) is required.
The power consumption should be logged as soon as the outdoor air temperature reaches -15°C until the end of the test.
At an outdoor air temperature of -10°C the power consumption should be logged additionally for a defined time frame (30 min).

**Required data/ documentation to be provided from the laboratory**

The test and documentation of the frost protection strategy should follow the existent description. The laboratory should provide the measured values in a form that allows examination (e.g. ms excel file).

**Source**

[1] Requirements and testing procedures for energetic and acoustical assessment of Passive House ventilation systems < 600 m³/h for Certification as „Passive House suitable component, Passivhaus Institut, 2009

Passivhaus Institut

Passivhaus Institut
Rheinstr. 44/46, 64283 Darmstadt
Tel +49 (0)6151/826 99 0
Fax +49 (0)6151/826 99-11
mail@passiv.de / www.passiv.de

# Requirements and testing procedures for the energetic and acoustic assessment of Passive House ventilation systems for certification as "Passive House suitable component"

## Supplementary Sheet Moisture Recovery for ventilation units < 600 m³/h

In order to determine the energy-relevant influence of ventilation units with moisture recovery in Passive Houses, the following additional regulations have been set up on the basis of comprehensive investigations. The general requirements and testing methods for the energetic and acoustic assessment of Passive House ventilation units for certification as "Passive House Suitable Components" are not affected by this supplement. The experimental set-up described in the main document applies for all tests, unless otherwise specified. For devices with a regenerative operation (rotors) the respective supplementary sheet is also to be considered.

In accordance with the general requirements and testing methods for the energetic and acoustic assessment of Passive House ventilation units for certification as "Passive House Suitable Components", the effective dry heat recovery efficiency is calculated when determining the thermodynamic characteristics.

The moisture recovery is determined for the standardised extract air conditions of 21°C/50% rH and for outdoor air conditions of 4°C/80% rH.

$$\eta_x = \frac{x_{AB} - x_{FO}}{x_{AB} - x_{AU}} \qquad [5]$$

For the energy-relevant assessment of moisture recovery with $\eta_x \leq 0{,}6$ the following rule applies:

$$\eta_{WRG,eff} = \eta_{WRG,t,eff} + 0{,}08 \cdot \eta_x \qquad [6]$$

For moisture recovery $\eta_x > 0{,}6$ the bonus is limited to a maximum of 4,8 %.

The heat recovery efficiency including the applicable allowance can be stated on the unit's certificate. The moisture recovery will be listed in the appendix to the certificate.

In order to prevent damage from occasional excessive humidity, units with a moisture recovery of $\eta_x > 0{,}6$ must have a regulated air flow rate, which is controlled by the indoor air humidity. For certification, the method of regulation should be explained.

Furthermore, the increased air change rate required to limit the indoor air humidity must be taken into account in energy balance calculations: Without reliable information, it can be presumed to be

$$\dot{V}_{eff} = \dot{V}_{hyg} \cdot \frac{0{,}4}{1-\eta_x} \qquad [7]$$

for residential use (35 m²/person, moisture generated ca. 2 g/(m²h)).

For devices with a high moisture recovery and special boundary conditions, particularly for adjustable moisture recovery, more favourable values can be calculated with an annual energy balance based on a dynamic hygrothermal building simulation in contrast to the more simplified method according to [6]. The Passive House Institute carries out such assessments on request.

## Symbols and abbreviations

| | | |
|---|---|---|
| $\eta_x$ | Moisture recovery | [-] |
| $x_{AB}$ | Absolute humidity extract air | [g/kg] |
| $x_{FO}$ | Absolute humidity exhaust air | [g/kg] |
| $x_{AU}$ | Absolute humidity outdoor air | [g/kg] |
| $\dot{V}_{eff}$ | Effective air flow rate | [m³/h] |
| $\dot{V}_{hyg}$ | Air flow rate required for hygienic reasons | [m³/h] |
| $\eta_{WRG,eff}$ | Certifiable effective heat recovery efficiency | [-] |
| $\eta_{WRG,t,eff}$ | Effective dry heat recovery efficiency | [-] |

Passive House Institute
Rheinstr. 44/46, 64283 Darmstadt
Tel +49 (0)6151/826 99 0
Fax +49 (0)6151/826 99-11
mail@passiv.de / www.passiv.de

# Reuqirements and testing procedure for the energetic and acoustic assessment of Passive House ventilation units for certification as "components suitable for Passive Houses"

## Supplementary sheet for regenerative HR < 600 m³/h - Preliminary

For determining the characteristics of home ventilation units with regenerative heat recovery, particular consideration needs to be given to some special features which sometimes make it necessary to modify and amend the procedure for the requirements and the testing procedures for the energetic and acoustic assessment of Passive House ventilation units for certification as "components suitable for Passive Houses". The rules for the general testing procedures apply as long as any special features are not specified.

### Prevention of ice build-up in the heat exchanger

For units that ensure the prevention of ice build-up in the heat exchanger without any auxiliary devices, the experiments given in the testing regulations are carried out without these devices, and their effectiveness is verified by means of measurements.

### Electrical efficiency

In order to show the influence of auxiliary drives in regenerative devices (rotor drive, dampers), an additional measurement of the electrical power consumption at the lower limit of the operational range is necessary. The limit value of 0.45Wh/m³ must be complied with.

### Internal leakages / transfer of exhaust air

The transfer of exhaust air should be determined by measuring. This is done using the tracer gas method based on EN 308. However, the following boundary conditions should be set differently from the standard: the volumetric flow should correspond with the upper limit of the operational range, balanced operation on the outdoor air/exhaust air side and external pressure as given in the testing regulations.

The leakage rate must not exeed 3 % of the mean air flow rate of the operational range. By designing of the unit accordingly (consideration of fan positioning use of a purging chamber) it is possible to achieve much better values (<0,5 %) which is recommended by PHI.

For devices with discontinuous operation, the effective average value should be ascertained over a sufficiently long measurement period.

Inherent to regenerative heat recovery systems is the possibility of water soluble odorous substances being transferred from extract air to supply air is given. These are mainly food odours that occur in the kitchen extract air

The applicability of regenerative heat recovery systems has to be assessed specifically for each project especially if one heat recovery ventilation unit supplies more than one (dwelling) unit.

**External leakage**

The external leakage is determined in accordance with the Nord Test Method as given in the testing regulations. In principle, the tracer gas method may also be used if this simplifies the measurements. However, pressure differences should be applied in a similar way.

**Moisture transfer**

Transfer of moisture is likely to occur in regenerative heat recovery systems due to the design of the device. The moisture recovery $\eta_x$ should be determined in accordance with the regulations in the supplementary sheet for moisture recovery. The requirements for the control of moisture as given there and the procedures for taking into account the enthalpy transfer apply when determining the effective heat recovery rate.

For devices with discontinuous operation, the effective average value of moisture transfer should be determined over a sufficiently long measurement period.

**Purging air and heat recovery rate**

In order to prevent the transmission of extract air towards the supply air, the regenerator is usually flushed with outdoor air. The mass flows of outdoor and exhaust air differ from the mass flows of the supply air and extract air by the amount of purging air even with ideal air tightness of the device.

$$\dot{m}_{Spül} = \dot{m}_{AU} - \dot{m}_{ZU} \quad [8]$$

The determination of the operational range is not affected by this; here the reference value is the volumetric supply air flow.

However, the determination of the effective heat recovery rate requires the taking into account of the quantity of purging air.

The following applies for balanced the mass flows:

$$\eta_{WRG,t,eff} = \frac{\dot{m}_{ZU} \cdot \vartheta_{AB} + \dot{m}_{Spül} \cdot \vartheta_{AU} - \dot{m}_{AU} \cdot \vartheta_{FO} + \frac{P_{el}}{c_p}}{\dot{m}_{ZU} \cdot (\vartheta_{AB} - \vartheta_{AU})}$$

$$\eta_{HR,d,eff} = \frac{\dot{m}_{SUP} \cdot \vartheta_{ETA} + \dot{m}_{Cl} \cdot \vartheta_{ODA} - \dot{m}_{ODA} \cdot \vartheta_{EHA} + \frac{P_{el}}{c_p}}{\dot{m}_{SUP} \cdot (\vartheta_{ETA} - \vartheta_{ODA})} \quad [9]$$

The taking into account of a measured disbalance for constant-controlled fans takes place through the consideration of the exhaust air mixing temperature $\vartheta_{FO,korr}$ depending on the disbalance $\dot{m}_{Dis}$.

$$\dot{m}_{Dis} = \dot{m}_{AU} - \dot{m}_{FO} \quad [10]$$

$$\vartheta'_{FO,korr} = \frac{\vartheta_{FO} \cdot \dot{m}_{FO} + (\dot{m}_{Dis}) \cdot \vartheta_{AB}}{\dot{m}_{FO} + (\dot{m}_{Dis})} \quad [11]$$

The effective dry heat recovery rate is finally determined by applying the mixing temperature thus ascertained:

$$\eta_{WRG,t,eff} = \frac{\dot{m}_{ZU} \cdot \vartheta_{AB} + \dot{m}_{Spül} \cdot \vartheta_{AU} - \dot{m}_{AU} \cdot \vartheta_{FO,korr} + \frac{P_{el}}{c_p}}{\dot{m}_{ZU} \cdot (\vartheta_{AB} - \vartheta_{AU})} \quad [12]$$

The present additional information regarding ventilation units with regenerative functioning for the purpose of certification as Passive House suitable components are preliminary. In case of doubt or uncertainties, the PHI should be consulted before carrying out measurements.

## Symbols and abbreviations

| | | |
|---|---|---|
| $\eta_x$ | Humidity conditions | [-] |
| $\dot{m}_{ZU}$ | Supply air mass flow | [kg/h] |
| $\dot{m}_{Spül}$ | Scavenging air mass flow | [kg/h] |
| $\dot{m}_{AU}$ | Outdoor air mass flow | [kg/h] |
| $\dot{m}_{Dis}$ | Disbalance mass flow | [kg/h] |
| $\dot{m}_{FO}$ | Exhaust air mass flow | [kg/h] |
| $\vartheta_{AB}$ | Extract air temperature | [°C] |
| $\vartheta_{AU}$ | Outdoor air temperature | [°C] |
| $\vartheta_{FO}$ | Exhaust air temperatur | [°C] |
| $\vartheta_{FO,korr}$ | Exhaust air mixing temperature | [°C] |
| $P_{el}$ | Electric power consumption | [W] |
| $c_p$ | Specific heat capacity of air | [W·h/(kg·K)] |
| $\eta_{WRG,t,eff}$ | Effective heat recovery rate | [-] |

Passive House Institute
Rheinstrasse 44/46, 64283 Darmstadt
Tel +49 (0)6151/826 99 0
Fax +49 (0)6151/826 99-11
mail@passiv.de / www.passiv.de

# Requirements and test procedures for energy relevant and acoustic assessment of Passive House ventilation units for certification as Passive House Components

## Supplementary sheet for the efficiency ratio - provisional

The efficiency ratio is used for the overall energy relevant assessment of a ventilation unit. It specifies the amount by which the energy demand caused by ventilation can be reduced through the use of a ventilation unit with heat recovery.

The efficiency ratio takes into account the final energy demand for covering the ventilation heat losses and the necessary auxiliary energy for the ventilation unit and the frost protection strategy. Because heat supply takes place with a heat pump, only electrical energy is incurred (different approaches for primary energy factors therefore do not play any role). The efficiency ratio is determined using a representative data set for the relevant climate zone.

The efficiency ratio is calculated in accordance with the following formula:

$$\boldsymbol{\varepsilon} = \frac{\boldsymbol{Q_{V,end,ref} - Q_{V,end,HR} - Q_{rv,aux} - Q_{rv,defrost}}}{\boldsymbol{Q_{V,end,ref}}}$$

| | |
|---|---|
| $Q_{V,end,ref}$ | Final energy demand for covering the ventilation heat losses of a reference system without heat recovery [kWh/a] |
| $Q_{V,end,HR}$ | Final energy demand for covering the ventilation heat losses of the ventilation system with heat recovery [kWh/a] |
| $Q_{rv,aux}$ | Energy demand of the ventilation unit in the heating period [kWh/a] |
| $Q_{rv,defrost}$ | Energy demand of the frost protection strategy for the heat exchanger [kWh/a] |

With the following calculation approaches:

$Q_{V,end,HR} = V \cdot n \cdot c \cdot (1 - \eta_{HR}) \cdot G_t \cdot e_H$
$Q_{V,end,ref} = V \cdot n \cdot c \cdot G_t \cdot e_H$

$V \cdot n = 1\, m^3/h$
$c = 0.33\, Wh/(m^3K)$

| | |
|---|---|
| $\eta_{HR}$ | measured heat recovery efficiency (according to the PHI test regulations) [-] |
| $G_t$ | heating degree hours in accordance with the climate zone [kKh/a] |
| $e_H = 0.44$ | performance ratio of the electric heat pump heating system [-] |

$Q_{rv,aux} = 0.001 \cdot V \cdot n \cdot P_{el} \cdot t_H$

| | |
|---|---|
| $P_{el}$ | measured specific electrical power consumption of the ventilation unit (according to the PHI test regulations) [W/(m³/h)] |
| $t_H$ | duration of the heating period (for ventilation system operation) according to the climate zone [h] |

$Q_{rv,defrost}$ energy demand for the frost protection strategy [kWh/a]. Calculation algorithm according to [PHPP]

Frost protection strategy: the following switch-on points are used depending on the foreseen frost protection strategy.

| Frost protection strategy | **Switch-on point outside air temperature [°C]** |
|---|---|
| Rotor/regenerative heat exchanger | < -15 °C |
| Recuperative heat exchanger with moisture recovery | Ca. -8 °C |
| Recuperative heat exchanger without moisture recovery | -3 °C |
| Recuperative heat exchanger without moisture recovery | -1.5 °C |
| Recuperative heat exchanger without moisture recovery | -1 °C |

For recuperative heat exchangers without moisture recovery a general switch-on temperature of -1.5°C is assumed initially; lower switch-on temperatures can be taken into account later on after verification. Please contact us for this.

Climate data:

Climate zone cool, temperate (representative location: Frankfurt am Main):

$G_t$ = 79 kKh/a, $t_H$= 5136 h

Passive House Institute
Rheinstr. 44/46, 64283 Darmstadt
Germany
Tel +49 (0)6151/826 99 0
Fax +49 (0)6151/826 99-11
mail@passiv.de / www.passiv.de

# Requirements and test procedures for energy relevant and acoustic assessment of Passive House ventilation units for certification as Passive House Components

## Supplementary sheet for hot and very hot climates - provisional

**25.05.2016**

The following and to some extent different requirements and test procedures result for hot and very hot climates with reference to:

- Thermodynamic testing
- Moisture recovery
- Heat recovery bypass
- Electrical efficiency
- Hygiene

We recommend that proof of testing and verification as described in this supplementary sheet for certification in hot or very hot climates is provided in addition to certification for cool, temperate climates as both requirements may exist in many regions.

### 1. Thermodynamic testing

The external pressure difference to be applied for the measurements is generally 100 Pa. The applied external pressure drop should be uniformly distributed (i.e. about 50 % each) between the suction and discharge sides.

- All volumetric flows (ODA/EHA + SUP/ETA) should be measured and recorded.
- Air temperature and humidity should be measured and recorded for all volumetric flows (ODA/EHA + SUP/ETA).
- The total electrical power consumption of the device (including the control unit, possible also any necessary external systems etc.) should be determined and recorded.

The following (dry) temperature and moisture conditions should be set:

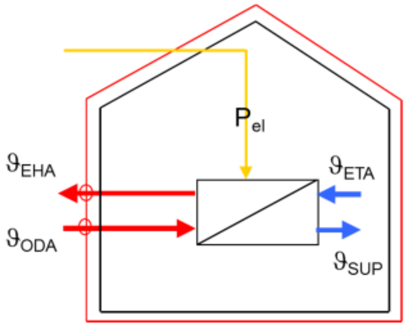
a) Measurement under indoor conditions

The outdoor air and exhaust air mass flows should be adjusted according to the device settings within the limits of measurement accuracy.

Outdoor air conditions $\vartheta_{ODA}$ = 35 °C with a relative humidity ≤ 50%

Extract air temperature $\vartheta_{ETA}$ = 25 °C with a relative humidity ≈ 50%

Ambient air = Extract air




**Calculating the heat recovery on cooling**

$$\eta_{HR(\text{hot climates})} = \frac{(\vartheta_{AB} - \vartheta_{FO}) + \frac{P_{el}}{\dot{m} \cdot c_p}}{\vartheta_{ETA} - \vartheta_{ODA}} \qquad [1]$$

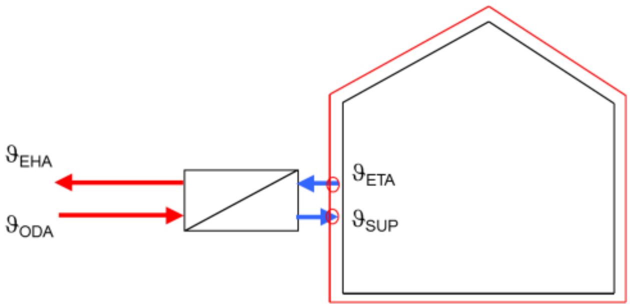
b) Alternatively, the measurement can also be performed under outdoor air conditions

The outdoor air and exhaust air mass flows should be adjusted according to the device settings within the limits of measurement accuracy.

Outdoor air conditions $\vartheta_{ODA}$ = 35 °C with a relative humidity ≤ 50%

Extract air temperature $\vartheta_{ETA}$ = 25 °C with a relative humidity ≈ 50%

Ambient air = Outdoor air




**Calculating the heat recovery on cooling**

$$\eta_{HR(\text{hot climates})} = \frac{\vartheta_{SUP} - \vartheta_{ODA}}{\vartheta_{ETA} - \vartheta_{ODA}} \qquad [2]$$

For all measurement series it should be ensured and verified through the recorded measured data that the overall test setup has reached a steady state.

For certification as a Passive House component, the calculated heat recovery on cooling must be 70 % or more.

## 2. Moisture recovery

For application in hot and humid climates, the use of heat exchangers with moisture recovery is necessary or at least strongly recommended in order to reduce to a minimum the entry of moisture into the home from outside.
The moisture recovery rate should be determined by measurements under the following boundary conditions (test setup and measurement similar to 1.).

Outdoor air $\vartheta_{\mathrm{ODA}}$ = 35 °C with a relative humidity = 80%

Extract air $\vartheta_{\mathrm{ETA}}$ = 25 °C with a relative humidity = 50%

Finally, the moisture recovery rate should be determined according to the following equation:

$$\eta_x = \frac{x_{ODA} - x_{SUP}}{x_{ODA} - x_{ETA}} \qquad [2]$$

The moisture recovery rate should be better than 60%.

## 3. Heat recovery bypass

Checking of the effectiveness of the heat recovery by pass for night-time cooling under the following conditions:

Extract air $\vartheta_{\mathrm{ETA}}$ = 25 °C
Outdoor air $\vartheta_{\mathrm{ODA}}$ = 16 °C
Volumetric flow at the upper operating limit
Bypass damper opened 100%

The supply temperature should be measured in order to determine the rise in temperature of the supply air temperature compared to the outdoor air temperature.

## 4. Elektroeffizienz

The total electrical power consumption of the ventilation unit (both fans, including the control unit, possibly also any necessary external systems) for the volumetric flow may not exceed the upper limit of the operating range of 0.45 W per (m³/h) of transferred supply air volume flow (recommendation for hot and very hot climates ≤ 0.35 Wh/m³). The test should be carried out at an external pressure of 100 Pa.

## 5. Hygiene

**Filter**

To protect the heat exchanger and the supply air duct network, a fine filter with Class F7 or better should be foreseen on the outdoor air side (corresponding with ASHRAE MERV 13 or better, or with EN779 E1 or better).
If the device itself does not provide the possibility of inserting a F7 filter then an external filter box should be recommended by the manufacturer. This must also be installed for the above-mentioned tests.

**Condensate drain**

For use in hot and humid climates or also in warm climates with moderate or only temporarily high air humidity levels, equipping the device with a condensate drain is strongly recommended.

a) The condensate drain should be implemented so that the condensate can drain away completely. The installation measures necessary for this should be clearly described in the instruction manual for the device.
b) The inner surfaces of the device housing, particularly on the supply air side should be smooth and easy to clean. Easy access to the device must be possible for maintenance and cleaning purposes (preferably without the need for tools).
c) The condensate drain should preferably be manufactured with a ball siphon or similar in order to prevent odour. The necessary accessories are either supplied by the manufacturer or a product will be recommended by the manufacturer.

Proof relating to a) and b) should be provided through corresponding device drawings and specifying of the materials of the device housing.

**Symbols and abbreviations**

| | | |
|---|---|---|
| $\eta_{HR(hot\ climates)}$ | Heat recovery on cooling | [%] |
| $\vartheta$ | Temperature | [°C] |
| ODA | Outdoor air | |
| SUP | Supply air | |
| ETA | Extract air | |
| EHA | Exhaust air | |
| $\eta_x$ | Moisture recovery rate | [-] |
| $x$ | Absolute humidity | [g/kg] |